Temperature and pCO2 effects on survivability of 25 genotypes of Acropora cervicornis coral at Mote Marine Laboratory in Nov-Dec 2019

Website: https://www.bco-dmo.org/dataset/871765
Data Type: Other Field Results, experimental
Version: 1
Version Date: 2022-03-18

Project
» CAREER: Applying phenotypic variability to identify resilient Acropora cervicornis genotypes in the Florida Keys (Resilient Acerv)

Contributors	Affiliation	Role
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Abstract
** Please write a dataset-specific abstract ** A full factorial experiment was completed at Mote Marine Laboratory in November and December 2019 to determine the survival probability and photochemical efficiency of 25 unique genotypes of Acropora cervicornis in high temperature, high pCO2 treatment, or the combination of high temperature and high pCO2.

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Coverage

Spatial Extent: **Lat**:24.6616 **Lon**:-81.4541
Temporal Extent: 2019-11-18 - 2019-12-19

Methods & Sampling

A full factorial experiment was completed to determine the survival probability and photochemical efficiency of 25 unique genotypes of *Acropora cervicornis* in high temperature, high pCO_2 treatment, or the combination of high temperature and high pCO2.

- High temperature was 33 ± 0.6°C and 463 ± 31 µatm
- High pCO_2 treatment was 29 ± 0.2°C and 798 ± 78 µatm
- Combination high temperature and high pCO2 was 33 ± 0.8°C and 823 ± 83 µatm

Prior to exposure, dark-acclimated photochemical efficiency was measured in all fragments (n=600) using a pulse amplitude modulation chlorophyll fluorometer (I-PAM, Walz GmbH, Effeltrich, Germany). Photochemical efficiency factors include:

- $ETR_{(max)}$
- $F_v/F_{m\ (max)}$
- Initial slope of ETR v. PAR plot

Additionally, the starting color index was gathered for each fragment based on the coral health chart provided by CoralWatch. The starting colors ranged from D1 for bleached to D5 for full color/healthy. During the exposure period, water quality for each tank was measured daily and color index was assessed daily for all fragments. Water samples were collected in acid-washed amber bottles (125 mL) for carbonate chemistry analysis bi-weekly and fixed with mercuric chloride (60 µL). Water samples were filtered (0.2 microns) prior to analysis on the dissolved inorganic carbon (DIC) machine (Apollo SciTech Analyzer).

As replicates started to show signs of stress (paling activity) and subsequent mortality, the following was recorded:

- the date of mortality,
- the time (days) till mortality,
- the mechanism of mortality (i.e. showed signs of Tissue loss, Bleaching, or both occurring simultaneously)

Each replicate coral was categorized as a binomial rank, classified as either 0, no event/alive, or a 1, event occurred/dead, on each day of the study. As coral fragments reached mortality, they were removed from their treatment tank to limit negative effects on the remaining fragments in the tank. Once LD50 was reached for each genotype in each treatment, the dark-acclimated PAM Chlorophyll Fluorometry outputs ($ETR_{(max)}$, $F_v/F_{m\ (max)}$, and initial slope of ETR v. PAR plot) was measured for the remaining fragments of that genotype in that same treatment to derive change of yield over time.

Treatment tank water quality was monitored using a YSI Professional Plus (Pro Plus) Multi-parameter handheld with a quarto containing a Pro Series Galvanic Dissolved Oxygen Sensor, a Pro Series pH Sensor (calibrated using 4, 7, and 10 buffers), Pro Series temperature and conductivity sensor. PAR was measured using the Licor handheld (Li-COR LI-1500) with an underwater quantum senor (Li-Cor LI-192). Dissolved inorganic carbon (DIC) was analyzed using the Apollo SciTech DIC analyzer model AS-C151. Total Alkalinity (TA) was analyzed using the Metrohm 905 Titrando analyzer. Both DIC and TA were standardized each day with certified reference material (CRM) provided by A.G. Dickson. Imaging-PAM Chlorophyll flurometer (Walz GmbH, Effeltrich, Germany) was used to measure photochemical efficiencies and the coral health chart/ color index card was provided by CoralWatch.

Data Processing Description

Kaplan Meier curves and log rank scores were used to assess the difference in survivorship among genotypes, regions, and treatments. If assumptions were met, ANOVA and Tukeys post-hoc test was used to measure the effect of Genotype, Region, and Treatment (singularly and interaction effect) on photochemical efficiencies; tank number as a random factor. Normality and equality of variances were checked using Shapiro-wilks test and Levene's test, respectively. If assumptions were not met, a Kruskal Wallis test and Dunn's post-hoc test was used. Chi squared test was used to assess the independence between the frequency of each mechanism of mortality and Treatment and/or Region. If assumptions were not met, a Fishers exact test was used. All statistical analysis was completed in R version 4.0.3.

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Related Publications

R Core Team (2020). R: A language and environment for statistical computing. R v4.0.3. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/
Software

Siebeck, U. E., Marshall, N. J., Klüter, A., & Hoegh-Guldberg, O. (2006). Monitoring coral bleaching using a colour reference card. Coral Reefs, 25(3), 453–460. doi:10.1007/s00338-006-0123-8
Methods

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Related Datasets

IsSupplementedBy

Muller, E. M., Petrik, C. (2022) **Aquaria water quality PAR measurements from full factorial study of Acropora cervicornis at Mote Marine Laboratory in Nov-Dec 2019.** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2022-04-22 http://lod.bco-dmo.org/id/dataset/873446 [view at BCO-DMO]
Relationship Description: Water quality measurements of PAR for the full factorial study

Muller, E. M., Petrik, C. (2022) **Aquaria water quality pH and dissolved oxygen measurements from full factorial study of Acropora cervicornis at Mote Marine Laboratory in Nov-Dec 2019.** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2022-04-22 http://lod.bco-dmo.org/id/dataset/873433 [view at BCO-DMO]
Relationship Description: Water quality measurements of pH and dissolved oxygen for the full factorial study

Muller, E. M., Petrik, C. (2022) **Aquaria water quality total alkalinity, DIC, and CO2 measurements from full factorial study of Acropora cervicornis at Mote Marine Laboratory in Nov-Dec 2019.** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2022-04-22 http://lod.bco-dmo.org/id/dataset/873459 [view at BCO-DMO]
Relationship Description: Water quality measurements of total alkalinity, DIC, and CO2 for the full factorial study

Muller, E. M., Petrik, C. (2022) **Pilot study with three unique genotypes of Acropora cervicornis coral to determine survival probability after exposure to temperature treatments at Mote Marine Laboratory in September and October 2019.** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2022-03-18 http://lod.bco-dmo.org/id/dataset/871719 [view at BCO-DMO]
Relationship Description: Pilot study that preceded the full factorial experiment

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Parameters

Parameter	Description	Units
Latitude	Latitude	decimal degrees
Longitude	Longitude	decimal degrees
Tank_num	Number of assigned tank for experiment	unitless
Genotype	Number of coral genotype	unitless
Genotype_ID	Initials of genus and species plus genotype number	unitless
Replicate	Number of replicate assigned	unitless
Temp_treatment	Aquarium temperature conditions (ambient or high temperature)	unitless
pCO2_treatment	Aquarium pCO2 conditions (ambient or high pCO2)	unitless
Outcome	Status of the coral replicate at the end of the experiment (i.e. Dead, Pale, Sampled, Alive)	unitless
Start_Date	Start date of experiment when corals were put into aquariums	unitless
Mortality_Date	Date when mortality occurred	unitless
Time_till_mortality	Time in days from start date of experiment until date of mortality	days
Mechanism_of_Mortality	Cause of the mortality (TR=tissue loss, X=signs of paling before tissue loss, Y=tissue loss before showing signs of paling, A=abrupt bleaching, B=bleached)	unitless
Pre_Exposure_ETR	Electron transport rate (ETR) prior to exposure to treatments	unitless
Post_Exposure_ETR	Electron transport rate (ETR) after exposure to treatments	unitless
Change_in_ETR	Difference in electron transport rate (ETR) between pre and post exposure	unitless
Pre_Exposure_Initial_Slope	Initial slope of ETR vs. PAR plot using values prior to exposure to treatments	unitless
Post_Exposure_Initial_Slope	Initial slope of ETR vs. PAR plot using value after exposure to treatments	unitless
Change_in_Initial_Slope	Difference in initial slope between pre and post exposure	unitless
Pre_Exposure_Fv_Fm	Maximum quantum yield (Fv/Fm) prior to exposure to treatments	unitless
Post_Exposure_Fv_Fm	Maximum quantum yield (Fv/Fm) after exposure to treatments	unitless
Change_in_Fv_Fm	Difference in maximum quantum yield (Fv/Fm) between pre and post exposure	unitless

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Instruments

Dataset-specific Instrument Name	treatment tanks
Generic Instrument Name	Aquarium
Dataset-specific Description	Coral fragments were placed into treatment tanks (raceways)
Generic Instrument Description	Aquarium - a vivarium consisting of at least one transparent side in which water-dwelling plants or animals are kept

Dataset-specific Instrument Name	Metrohm 905 Titrando analyzer
Generic Instrument Name	Automatic titrator
Dataset-specific Description	Total Alkalinity (TA) was analyzed using the Metrohm 905 Titrando analyzer.
Generic Instrument Description	Instruments that incrementally add quantified aliquots of a reagent to a sample until the end-point of a chemical reaction is reached.

Dataset-specific Instrument Name	Walz imaging pulse amplitude modulation chlorophyll fluorometer
Generic Instrument Name	Fluorometer
Dataset-specific Description	Photochemical efficiencies in coral fragments were measured using an Imaging Pulse Amplitude Modulation (I-PAM) Chlorophyll fluorometer from Walz GmbH (Effeltrich, Germany)
Generic Instrument Description	A fluorometer or fluorimeter is a device used to measure parameters of fluorescence: its intensity and wavelength distribution of emission spectrum after excitation by a certain spectrum of light. The instrument is designed to measure the amount of stimulated electromagnetic radiation produced by pulses of electromagnetic radiation emitted into a water sample or in situ.

Dataset-specific Instrument Name	Apollo SciTech DIC analyzer model AS-C151
Generic Instrument Name	Inorganic Carbon Analyzer
Dataset-specific Description	Dissolved inorganic carbon (DIC) was analyzed using the Apollo SciTech DIC analyzer model AS-C151.
Generic Instrument Description	Instruments measuring carbonate in sediments and inorganic carbon (including DIC) in the water column.

Dataset-specific Instrument Name	LI-COR LI-192 underwater quantum sensor
Generic Instrument Name	LI-COR LI-192 PAR Sensor
Dataset-specific Description	PAR was measured using the Licor handheld (Li-COR LI-1500) with an underwater quantum senor (Li-Cor LI-192).
Generic Instrument Description	The LI-192 Underwater Quantum Sensor (UWQ) measures underwater or atmospheric Photon Flux Density (PPFD) (Photosynthetically Available Radiation from 360 degrees) using a Silicon Photodiode and glass filters encased in a waterproof housing. The LI-192 is cosine corrected and features corrosion resistant, rugged construction for use in freshwater or saltwater and pressures up to 800 psi (5500 kPa, 560 meters depth). Typical output is in um s-1 m-2. The LI-192 uses computer-tailored filter glass to achieve the desired quantum response. Calibration is traceable to NIST. The LI-192 serial numbers begin with UWQ-XXXXX. LI-COR has been producing Underwater Quantum Sensors since 1973. These LI-192 sensors are typically listed as LI-192SA to designate the 2-pin connector on the base of the housing and require an Underwater Cable (LI-COR part number 2222UWB) to connect to the pins on the Sensor and connect to a data recording device. The LI-192 differs from the LI-193 primarily in sensitivity and angular response. 193: Sensitivity: Typically 7 uA per 1000 umol s-1 m-2 in water. Azimuth: < ± 3% error over 360° at 90° from normal axis. Angular Response: < ± 4% error up to ± 90° from normal axis. 192: Sensitivity: Typically 4 uA per 1000 umol s-1 m-2 in water. Azimuth: < ± 1% error over 360° at 45° elevation. Cosine Correction: Optimized for underwater and atmospheric use. (www.licor.com)

Dataset-specific Instrument Name	LI-COR handheld (Li-COR LI-1500)
Generic Instrument Name	Photosynthetically Available Radiation Sensor
Dataset-specific Description	PAR was measured using the Licor handheld (Li-COR LI-1500) with an underwater quantum senor (Li-Cor LI-192).
Generic Instrument Description	A PAR sensor measures photosynthetically available (or active) radiation. The sensor measures photon flux density (photons per second per square meter) within the visible wavelength range (typically 400 to 700 nanometers). PAR gives an indication of the total energy available to plants for photosynthesis. This instrument name is used when specific type, make and model are not known.

Dataset-specific Instrument Name	YSI Professional Plus (Pro Plus) Multi-parameter handheld
Generic Instrument Name	YSI Professional Plus Multi-Parameter Probe
Dataset-specific Description	Treatment tank water quality was monitored using a YSI Professional Plus (Pro Plus) Multi-parameter handheld with a quarto containing a Pro Series Galvanic Dissolved Oxygen Sensor, a Pro Series pH Sensor, and a Pro Series temperature and conductivity sensor
Generic Instrument Description	The YSI Professional Plus handheld multiparameter meter provides for the measurement of a variety of combinations for dissolved oxygen, conductivity, specific conductance, salinity, resistivity, total dissolved solids (TDS), pH, ORP, pH/ORP combination, ammonium (ammonia), nitrate, chloride and temperature. More information from the manufacturer.

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Project Information

CAREER: Applying phenotypic variability to identify resilient Acropora cervicornis genotypes in the Florida Keys (Resilient Acerv)

Coverage: Florida Keys, Summerland Key, FL 24.563595°, -81.278572°

NSF Award Abstract:
Caribbean staghorn coral was one of the most common corals within reefs of the Florida Keys several decades ago. Over the last 40 years disease, bleaching, overfishing and habitat degradation caused a 95% reduction of the population. Staghorn coral is now listed as threatened under the U.S. Endangered Species Act of 1973. Within the past few years, millions of dollars have been invested for the purpose of restoring the population of staghorn coral within Florida and the U.S. Virgin Islands. Significant effort has been placed on maintaining and propagating corals of known genotypes within coral nurseries for the purpose of outplanting. However, little is known about the individual genotypes that are currently being outplanted from nurseries onto coral reefs. Are the genotypes being used for outplanting resilient enough to survive the three major stressors affecting the population in the Florida Keys: disease, high water temperatures, and ocean acidification? The research within the present study will be the first step in answering this critically important question. The funded project will additionally develop a research-based afterschool program with K-12 students in the Florida Keys and U.S. Virgin Islands that emphasizes an inquiry-based curriculum, STEM research activities, and peer-to-peer mentoring. The information from the present study will help scientists predict the likelihood of species persistence within the lower Florida Keys under future climate-change and ocean-acidification scenarios. Results of this research will also help guide restoration efforts throughout Florida and the Caribbean, and lead to more informative, science-based restoration activities.

Acropora cervicornis dominated shallow-water reefs within the Florida Keys for at least the last half a million years, but the population has recently declined due to multiple stressors. Understanding the current population level of resilience to three major threats - disease outbreaks, high water temperatures, and ocean acidification conditions - is critical for the preservation of this threatened species. Results from the present study will answer the primary research question: will representative genotypes from the lower Florida Keys provide enough phenotypic variation for this threatened species to survive in the future? The present proposal will couple controlled laboratory challenge experiments with field data and modeling applications, and collaborate with local educators to fulfill five objectives: 1) identify *A. cervicornis* genotypes resistant to disease, 2) identify *A. cervicornis* genotypes resilient to high water temperature and ocean acidification conditions, 3) quantify how high water temperature and ocean acidification conditions impact disease dynamics on *A. cervicornis*; 4) determine tradeoffs in life-history traits because of resilience factors; and 5) apply a trait-based model, which will predict genotypic structure of a population under different environmental scenarios.

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Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-1452538

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